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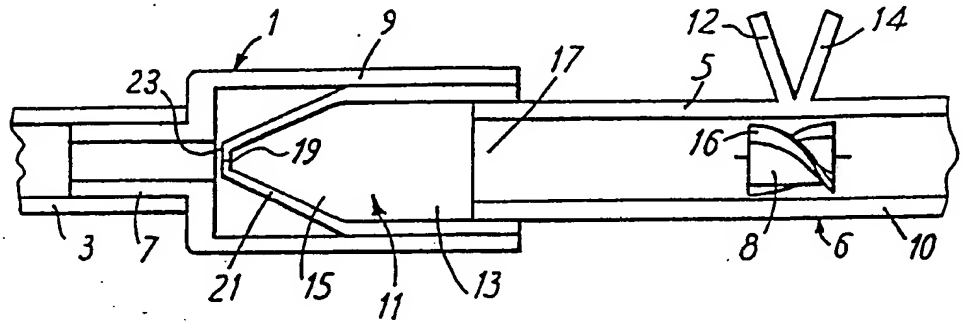

(57) Abstract

A flowmeter having a non-return valve suitable for use is systems for supplying fuel to petrol or diesel engines or systems for supplying spraying liquid to agricultural or horticultural spraying equipment. The valve includes a valve body having an inlet section formed with a fluid inlet and an outlet section having an end wall formed with fluid outlet means in the form of one or more slits. The outlet section is made up of one or more parts, each of which tapers in a direction from the fluid inlet towards the fluid outlet means. The or each part of the outlet section has an elongate end wall, which forms a part of the end wall of the body and is formed with a slit of the fluid outlet means, and two side walls, each of which slopes towards the associated end wall and terminates at a longitudinally extending side of the end wall. The end wall and side walls are made of resilient material. Each slit is closed when the pressure of fluid inside the outlet section is less than or equal to the pressure outside but opens when the pressure of fluid inside the outlet section is greater than the outside pressure.

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IMPROVEMENTS IN NON-RETURN VALVES

This invention relates to flowmeters having non-return valves.

In systems used for supplying fuel to many petrol or diesel engines, particularly those which employ an engine driven mechanically operated lift pump, the flow of fuel is subject to interruptions and there may even be a reversal of the flow of fuel.

This is partly because the pump itself causes pulsations, essentially at a frequency equal to one half of the engine r.p.m. Superimposed on these pulsations, however, are interruptions to the flow which are caused by the opening and closing of the carburettor needle valve or valves. The nature of these interruptions varies with the fuel demand of the engine and with vibration.

In addition, the column of fuel in the pipe leading from the tank to the carburettor almost invariably contains bubbles of petrol vapour and/or air. This has three effects. First, the fuel travels in spurts as each bubble of vapour or air reaches and passes through the carburettor needle valve. Secondly, the column of fuel, vapour and/or air is compressible. Finally, expansion of the compressed vapour and/or air tends to produce a localised reversal of flow on the suction stroke of the fuel pump.

Because of these pulsations, interruptions and reversals of the fluid flow, axial flow turbines, pelton wheels

and fan type inferential flowmeters currently used to measure the flow of fuel in internal combustion engines are subject to serious errors.

Thus, an axial flow turbine is not affected by sudden spurts in the flow rate since it cannot rotate faster than its natural speed for a given rate of flow of fluid past its vanes. It is, however, susceptible to flow reversals, particularly if the response rate is fast enough for the turbine to rotate in the reverse direction, the same volume of fuel being sensed and recorded for a second time when the turbine moves in the reverse direction and then again when it moves forwardly. This tendency to rotate in the reverse direction is greatest at low flow rates. The pelton wheel and fan type flowmeters are not so directly susceptible to a reversal in the flow of fuel owing to their greater inertia and hence slower response time. However, the fact that some fuel has moved in the reverse direction means that it is sensed and recorded for a second time when it moves forwardly again.

To overcome the above problems it is desirable to provide a non-return valve which allows fuel to flow readily in the forward direction whilst preventing, or substantially preventing, flow in the reverse direction.

According to the present invention there is provided a flowmeter having a non-return valve connected in series therewith and comprising a valve body having a fluid inlet, fluid outlet

means formed in an end wall of the body, and an outlet section, wherein the end wall comprises at least one elongate part formed with a slit which is comprised in the fluid outlet means and which extends lengthwise of the said part, and the outlet section comprises at least one part which tapers in a direction from the fluid inlet towards the fluid outlet means, the or each tapering part of the outlet section comprising a pair of side walls each of which slopes towards an associated elongate part of the end wall and terminates at a longitudinally extending side of the said part of the end wall, the said side walls and the said end wall of the body being formed by a resilient material and being so arranged that each slit is closed to prevent or substantially to prevent a flow of fluid through the slit when the fluid pressure inside the associated part of the outlet section is less than or equal to the pressure outside the body and each slit is forced open to allow fluid to flow through the slit when the fluid pressure inside the associated part of the outlet section is greater than the pressure outside the body.

Preferably, the end wall is formed of a single elongate part which extends through a longitudinal axis of the body, and the fluid outlet means are formed of a single slit which extends lengthwise of the said single part of the end wall.

Alternatively, the end wall comprises a plurality of elongate parts, each of the said parts extending outwardly from a location on a longitudinal axis of the body, and the fluid outlet

means comprise a plurality of slits, each formed in a respective one of the elongate parts.

Preferably, each of the said side walls is planar.

Preferably, the or each elongate part of the end wall has a width which is equal or substantially equal to twice the thickness of each of the pair of side walls associated therewith.

Suitably, the valve body also comprises a tubular inlet section, open at one end to form the said fluid inlet.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is an axial section of a flowmeter having a non-return valve according to the invention;

Figure 2 is a plan view of a valve body in the non-return valve of Figure 1;

Figures 3a, b and c are end views of the valve body of Figure 1 showing a fluid outlet of the body in closed, partially open and fully open positions; and

Figures 4 and 5 are perspective views of valve bodies in non-return valves in further flowmeters according to the invention.

Referring to Figure 1 of the drawings, a preferred form of flowmeter and non-return valve according to the invention is used in a system for supplying fuel from a tank to a petrol engine in a motor vehicle.

As shown in the drawing, a flowmeter 6 of the inferential type has a bladed rotor element 8 so arranged in a pipe 10 that fuel flowing along the pipe causes the element to rotate at an angular speed proportional to the rate of flow of fuel. In the flowmeter of Figure 1 the element 8 is a turbine, but the flowmeter could be a pelton wheel or fan type inferential flowmeter.

The speed of rotation of the rotor element 8 is detected by means of a beam of light which is directed on to the element 8 via a light guide 12. A radially outer face of each blade 16 on the element 8 moves across the light beam once during each rotation of the element. Light reflected from the blades 16 is directed via a further guide 14 to a photosensitive detector (not shown). An electrical output signal generated by the detector has a frequency proportional to the speed of rotation of the element 8, and hence proportional to the rate of flow of fuel.

Connected to an outlet 5 of the flowmeter 6 is a non-return valve 16. The valve 16 has a housing 1 which connects the outlet 5 to a pipe 3, which in turn is connected to a carburettor. The housing is made up of a short tubular inlet section 7 which is connected to the pipe 3 and a main section 9, which has a larger diameter than the section 7.

Fitted tightly within the main section 9 of the housing 1 is a valve body 11 which is formed by moulding and has an inlet

section 13 and an outlet section 15. The inlet section 13 is in turn fitted over the outlet 5 of the flowmeter.

The inlet section 13 of the body 11 is tubular and has an external diameter substantially equal to the internal diameter of the main section 9 of the housing 1. An opening at one end of the inlet section 13 serves as an inlet 17 to the body 11.

The outlet section 15 is formed as a single part which tapers in a direction from the fluid inlet 17 towards fluid outlet means in the form of a slit 19. The slit 19, which is preferably produced by a single knife cut after moulding the body 11, extends lengthwise of an elongate end wall 23, which is also formed as a single part and extends through the axis of the body 11. A pair of side walls 21 of the section 15 slope in a direction towards the end wall 23, each side wall being planar and terminating at a longitudinally extending side of the wall 23.

The housing 1 is made of a rigid metallic or plastics material and the valve body 11 is a moulding of a synthetic rubber, polyvinyl chloride or other resilient material which is not attacked by hydrocarbon fuels.

In use, fuel from the tank is pumped along the pipe leading towards the carburettor and flows through the outlet 5 of the flowmeter and into the inlet section 13 of the body 11. The shape of the outlet section 15 and the resilience of the material from which the section is made ensures that the outlet 19 remains

in its naturally closed position as long as the pressure applied to the fuel inside the body 11 is less than or equal to the pressure existing on the fuel downstream, ie. in the pipe 3. The condition is shown in Figure 3a. When the pressure of fuel inside the body 1 is increased to a value above the pressure downstream, however, the slit forming the outlet 19 begins to open. The situation when the outlet 19 is partially open is shown in Figure 3b and the situation when the differential pressure has increased still further and the outlet 19 is fully open is shown in Figure 3c.

The area of the aperture formed by the opening of the slit 19 is roughly proportional to rate of flow of fuel through the valve. As the flowmeter decreases towards the end of the fuel pump delivery stroke, the aperture begins to close until at the start of the suction stroke, when there is a tendency for the flow direction to reverse, the slit is almost completely closed. The final shut-off action under typical operating conditions of between 4 and 25 cycles per second (480 to 3,000 engine r.p.m.) is sufficiently rapid to prevent the return flow of any significant volume of fuel.

The preferred form of valve body 1 has an inlet section which is 0.6 inches long and an outlet section which is 0.7 inches long. In the inlet section 13 the side wall is 0.10 inches thick whilst each of the sloping side walls 21 in the outlet section 15 has a thickness of 0.03 inches. The end wall

of the outlet section 15 is 0.4 inches long and 0.05 inches wide.

In a pulsating flow as produced by a mechanical fuel pump, the instantaneous flow rate increases from zero to a peak and subsides again, following approximately the form of a sine wave. The opening of the slit 19 is such that the area of the aperture produced is roughly proportional to the flow rate.

In a valve of the dimensions described above, a gap of 0.005 inch at the centre of the slit is sufficient to pass a flow of 3 to 4 gallons per hour of petrol at average fuel pump pressure (3 to 7 P.S.I.).

Since the valve has virtually no inertia and the physical movement required to close the aperture is so small, it can effectively shut off any reversal of flow almost instantaneously.

Referring now to Figure 4 of the drawings, a valve body 25 in a second non-return valve according to the invention has an inlet section 27 and an outlet section 29.

The inlet section 27 corresponds to the inlet section 13 of the valve body described above, being tubular and having an opening (not shown) at one end which serves as an inlet to the body 25.

In the valve body 25 the outlet section 29 is formed of three parts 31, each of which tapers in a direction from the fluid inlet towards fluid outlet means 33. Each of the parts 31

has an elongate end wall part 35 and a pair of side walls 37. Each of the side walls 37 slopes towards the associated end wall part 35 and terminates at a longitudinally extending side of the end wall part.

Each of the end wall parts 35 extends radially outwardly from a location on the axis of the body 25. The parts 35 are equiangularly spaced and together form an end wall 39 of the valve body 25.

The fluid outlet means 33 are formed of three slits 41, each formed in and extending lengthwise of a respective one of the parts 35 of the end wall 39.

The valve body 25 is made of any one of the materials referred to above as being suitable for the body 11.

Operation of the valve body 25 is likewise similar to operation of the body 11. Each slit 41 remains closed when the fluid pressure inside the body 11 is less than or equal to the fluid pressure downstream of the body. When the pressure of fluid inside the body 11 is increased to a value above the pressure downstream, each of the slits 41 begins to open.

Figure 5 shows a valve body 43 which has an outlet section 45 formed of four tapering parts 47. Each part 47 has a pair of sloping side walls 49 and an end wall part 51 which extends radially outwardly from a location on the axis of the body 43. Formed in each end wall part 51 is a slit 53.

The valve body 43 is made of the same materials and

operates in a similar manner to the valve bodies 11 to 25' described above.

It will be appreciated that the non-return valves described above can be used in conjunction with flowmeters measuring the rate of supply of other liquids, for example the rate of supply of spraying liquid in agricultural and horticultural spraying equipment.

CLAIMS

1. A flowmeter having a non-return valve connected in series therewith and comprising a valve body having a fluid inlet, fluid outlet means formed in an end wall of the body, and an outlet section, wherein the end wall comprises at least one elongate part formed with a slit which is comprised in the fluid outlet means and which extends lengthwise of the said part, and the outlet section comprises at least one part which tapers in a direction from the fluid inlet towards the fluid outlet means, the or each tapering part of the outlet section comprising a pair of side walls each of which slopes towards an associated elongate part of the end wall and terminates at a longitudinally extending side of the said part of the end wall, the said side walls and the said end wall of the body being formed of a resilient material and being so arranged that each slit is closed to prevent or substantially to prevent a flow of fluid through the slit when the fluid pressure inside the associated part of the outlet section is less than or equal to the pressure outside the body and each slit is forced open to allow fluid to flow through the slit when the fluid pressure inside the associated part of the outlet section is greater than the pressure outside the body.

2. A flowmeter as claimed in claim 1, wherein the non-return valve is connected to an outlet of the flowmeter.

3. A flowmeter as claimed in claim 1 or 2, wherein the

or each slit is formed by a single cut in the associated elongate part of the end wall.

4. A flowmeter as claimed in claim 1, 2 or 3, wherein the end wall is formed of a single elongate part which extends through a longitudinal axis of the body, and the fluid outlet means are formed of a single slit which extends lengthwise of the said single part of the end wall.

5. A flowmeter as claimed in claim 1, 2 or 3, wherein the end wall comprises a plurality of elongate parts, each of the said parts extending outwardly from a location on a longitudinal axis of the body, and the fluid outlet means comprise a plurality of slits, each formed in a respective one of the elongate parts.

6. A flowmeter as claimed in any one of the preceding claims wherein each of the said side walls is planar.

7. A flowmeter as claimed in any one of the preceding claims, wherein the or each elongate part of the end wall has a width which is equal or substantially equal to twie the thickness of each of the pair of side walls associated therewith.

8. A flowmeter as claimed in any one of the preceding claims, wherein the valve body further comprises a tubular inlet section, open at one end to form the said fluid inlet.

9. A flowmeter constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

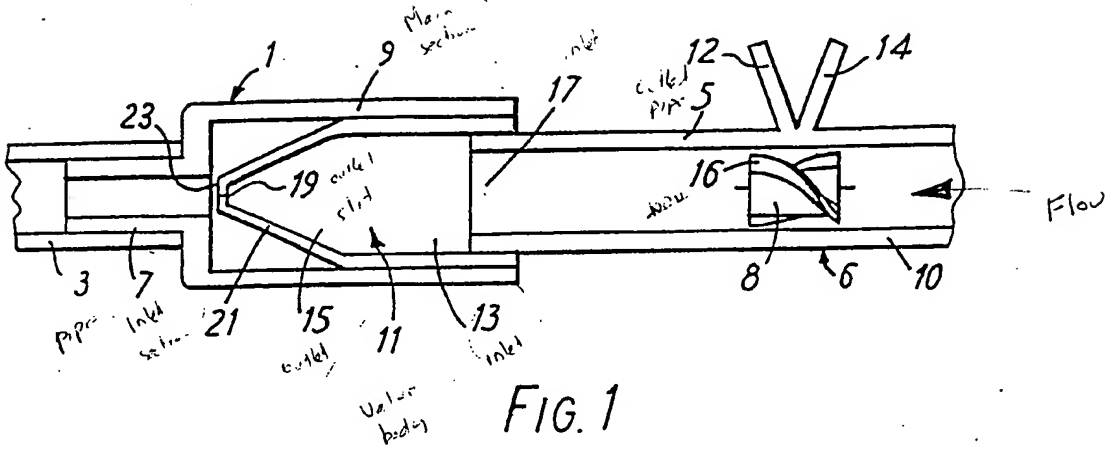

FIG. 1

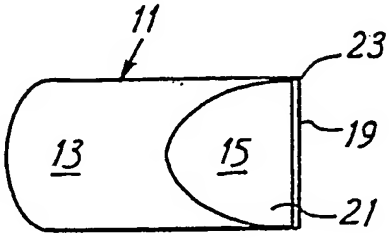

FIG. 2

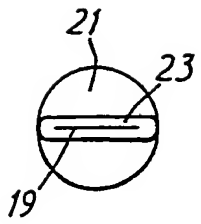

FIG. 3a

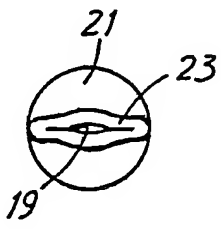

FIG. 4b

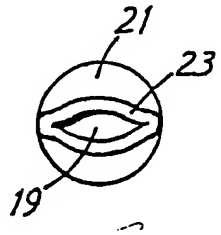

FIG. 5c

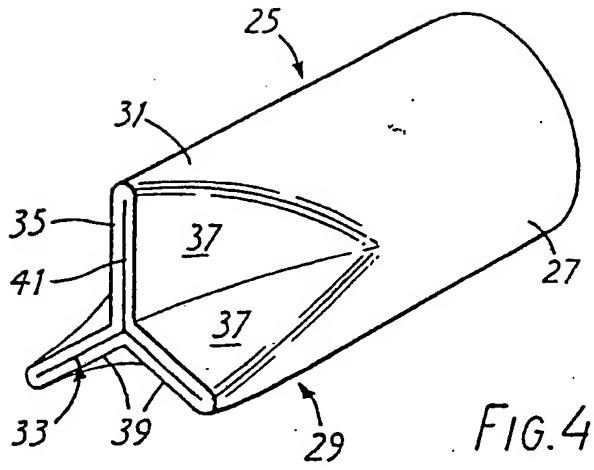

FIG.4

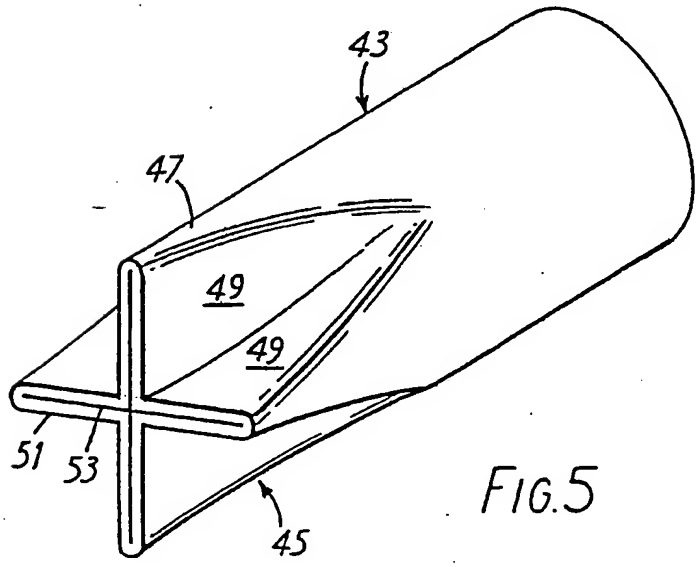

FIG.5

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 82/00355

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: G 01 F 15/00; G 01 F 1/72; F 16 K 15/14

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[3]	G 01 F; F 16 K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
E	EP, A, 0064331 (UNITED GAS INDUSTRIES PLC) 10 November 1982 see page 1, lines 1-6 and the figures; abstract; page 3, lines 5-6	1,2
Y	CH, A, 491369 (AQUAMETRO WASSERMESSER FABRIK AG) 15 July 1970 see page 1, column 1; figures	1,2,8,9
Y	DE, B, 1092221 (BOPP & REUTHER GmbH) 3 November 1960 see the entire document	1
Y	US, A, 2926692 (J.H. ZILLMAN et al.) 1 March 1960 see the figures	1,3-9
Y	GB, A, 1520354 (SWE-THERM AB) 9 August 1978 see page 1, lines 18-39; page 1, lines 58-79	1,3,4,6-9

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* Special categories of cited documents: [15]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [1]	Date of Mailing of this International Search Report [2]
24th March 1983	25 APR 1983
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

Form PCT/ISA/210 (second sheet) (October 1981)

FURTHER INFORMATION CONTINUED FRO.1 THE SECOND SHEET

Y	US, A, 2352642 (J.D. LANGDON) 4 July 1944, see figures; text	1,3-9

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers_____, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers_____, because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the International application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the International application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.